

>X-Sieve: CMU Sieve 2.3  
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>Date: Mon, 15 Sep 2008 11:42:57 -0400  
>Subject: Comments on Draft NCSTAR 1A and 1-9  
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>  
>WTC Technical Information Repository  
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>Stephen:  
>Please find attached my comments concerning the draft reports. I  
>hope they are of some help.  
>Best Regards  
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>  
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Comments on Draft NCSTAR 1A and NCSTAR 1-9 Submitted by				
Name:	Najib N. Abboud			
Affiliation:	Weidlinger Associates Inc.			
Contact:	abboud@wai.com			
EXTENT OF DEBRIS DAMAGE				
Comment:	The debris damage was more severe and widespread than indicated in several locations of the report. Based on NIST's assessment in NCSTAR 1-9 Fig. 5-83 (and related text) and NCSTAR 1A Fig. 2-1, the structural damage caused by debris impact includes seven bays over twelve floors in the southwest perimeter of WTC7, floors 44 to 47 over 2 bays in the south face, an 18 floor high gouge over 1 bay with possible structural damage, and possibly other damage in the unobservable areas encompassing nearly half the south face. The eyewitness account documented in NCSTAR 1-9, p. 301 (5th bullet) suggests that the 18 floor high gouge probably resulted in column impairment of columns 19 or 20.			
Reason for Comment:	Completeness			
Report #	Page #	Para./Sent.	Original Text	Suggestion for Revision
1A	xxxi	last par. / 2nd sent.	"The debris also caused some structural damage to the southwest perimeter of WTC 7."	Change to: "The debris also caused structural damage to the southwest perimeter of WTC 7 over twelve floors and seven bays, between floor 44 and the roof over two bays near the center on the south face, possibly along the 18 floor gouge in the center of the south face, and possibly in other, unobservable areas on the south face."
1A	xxxiii	3rd full par. /2nd sent.	"The building withstood debris impact damage that resulted in seven exterior columns being severed ..."	Change to: "The building withstood debris impact damage that resulted in at least seven exterior columns being severed plus substantial other structural damage ...
1A	14	5th par. /3rd sent.	"Pieces of WTC 1 hit WTC 7, severing six columns on Floors 7 through 17 on the south face and one column on the west face near the southwest corner. "	Add after 3rd sent: "The debris from WTC 1 also caused structural damage between floor 44 and roof over two bays near the center on the south face, possibly along the 18 floor gouge in the center of the south face, and possibly in other, unobservable areas on the south face."
1A	19	4th par. / 1st sent.	"The collapse of WTC 1 damaged seven exterior columns on the lower floors of the south and west faces of WTC 7 and initiated fires on 10 floors between Floors 7 and 30."	Change to: "The collapse of WTC 1 damaged seven exterior columns on the lower floors of the south and west faces of WTC 7, plus substantial other structural damage, and initiated fires on 10 floors between Floors 7 and 30."
1A and 1-9	1A (p43) and 1-9 (p. 609)	objective 1 /bullet 1	"WTC 7 withstood debris impact damage that resulted in seven exterior columns being severed and subsequently withstood ..."	Change to: "WTC 7 withstood debris impact damage that resulted in seven exterior columns being severed over twelve stories at the southwest perimeter, one column over four stories near the roof on the south face, possibly along the 18 floor gouge in the center of the south face, and possibly other columns in the unobservable areas on the south face. The building subsequently withstood ..."
1A and 1-9	1A (p46) and 1-9 (p612)	section 4.3.1 and 14.3.1/ bullet 2	"The structural damage to WTC 7 was primarily located at the southwest corner and adjacent areas of the west and south faces, on Floors 5 through 17. Severed columns were located between Floors 7 and 17 on the south face (six columns) and the west face (one column) near the southwest corner."	Add after 2nd sent: "The debris from WTC 1 also caused structural damage between floor 44 and roof over two bays near the center on the south face, possibly along the 18 floor gouge in the center of the south face, and possibly in other, unobservable areas on the south face."
1-9	601	1st par. /3rd sent.	"The collapse of WTC 1 damaged seven exterior columns on the lower floors of the south and west faces and initiated fires at five separate locations between Floors 7 and 30."	Change to: "The collapse of WTC 1 damaged seven exterior columns on the lower floors of the south and west faces of WTC 7, plus substantial other structural damage, and initiated fires on 10 floors between Floors 7 and 30."
1-9	602	2nd par. /2nd sent.	"The collapse of WTC 1 caused (1) structural damage that severed seven (out of 58) exterior columns on the lower floors of WTC 7;"	Change to: "The collapse of WTC 1 caused (1) structural damage that severed seven (out of 58) exterior columns on the lower floors of WTC 7, plus substantial other structural damage shown in Fig 5-83;"
DEGREE OF CERTAINTY REGARDING EXTENT OF DAMAGE TO THE SFRM				
Comment:	There is no direct evidence for the condition of the SFRM in WTC 7 after the collapse of WTC 1.			

<b>Reason for Comment:</b>	Clarification			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A and 1-9	1A (p44) and 1-9 (p610)	3rd full par./bullet 7 of objective 1	"Prior to its collapse, there had been no damage to the SFRM that was applied to the steel columns, girders, and beams, except in the vicinity of the structural damage from the collapse of WTC 1, which was near the west side of the south face of the building."	<i>Replace with:</i> "Based on the observed damage to the SFRM in Bankers Trust building, it was assumed that WTC 7, prior to its collapse, did not sustain damage to its SFRM applied to the steel columns, girders, and beams, except in the vicinity of the structural damage from the collapse of WTC 1."
<b>PROGRESSIVE COLLAPSE PROVISIONS</b>				
<b>Comment:</b>	Application of current progressive collapse provisions (e.g., GSA) to WTC 7 would not have prevented the collapse. The GSA progressive collapse provisions apply to exterior columns only, and the perimeter frame of WTC-7 clearly demonstrated its ability to resist substantial damage, much beyond what is contemplated by current progressive collapse provisions known to the industry. The report could be read to suggest that had current progressive collapse provisions been applied, the collapse would have been averted, and this is clearly not the case.			
<b>Reason for Comment:</b>	Completeness			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A	xxxii	1st full par./after last sentence		<i>Add a sentence after last sentence:</i> "It should be noted that application of current progressive collapse provisions, such as GSA provisions, would not have prevented this collapse."
1A and 1-9	1A (p 44) and 1-9 (p 612)	Objective 1 / 5th bullet		<i>Add paragraph from NCSTAR 1-1 (Sept 2005):</i> " Building codes lack explicit structural integrity provisions to mitigate progressive collapse. Federal agencies have developed guidelines to mitigate progressive collapse and routinely incorporate such requirements in the construction of new federal buildings." <i>Continue paragraph by adding:</i> "One such agency is the GSA. It should also be noted that WTC-7 would have been found in compliance with current GSA progressive collapse provisions since these apply to exterior columns. The ability of WTC 7 to sustain column loss in the exterior frame without progressive collapse was amply demonstrated on 9/11."
<b>COLLAPSE SEQUENCE</b>				
<b>Comment:</b>	The LS-DYNA analysis indicates that the horizontal progression of collapse occurs through a damage propagation through the upper floors and is not attributable to the "strong" floors between 5 & 7. NIST's preliminary results up to the technical presentation on Dec 18, 2007 (WTC 7 Working Collapse Hypothesis) could be misconstrued to mean that that absent such "strong" floors, the collapse might have remained confined to the bays adjoining columns 79-81.			
<b>Reason for Comment:</b>	Accuracy and Completeness			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A	39 and 44	39 (1st par.) and 44 (top of page)		<i>Add:</i> "The collapse analysis established that the "strong" floors (floors 5 and 7) are not the cause of the horizontal propagation of failure."
<b>Comment:</b>	The LS-DYNA analysis in Section 3.4.6 which incorporated the debris impact damage to the south face is more consistent with the observed collapse. That statement should be reflected in the global collapse summary on p 51.			
<b>Reason for Comment:</b>	Accuracy and Completeness			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A	51	1st par/2nd sent.	"The overall features and timing of the prediction were consistent with the videographic evidence."	<i>Replace with:</i> "The overall features and timing of the prediction were more consistent with the videographic evidence when the debris impact damage is taken into account in the computer analysis."

### EXTENT OF FIRE INDUCED DAMAGE

<b>Comment:</b>	Extensive thermal weakening and failure of connections and floor beams was not limited to the floor framing surrounding column 79. The NIST analyses also show extensive thermal weakening and failure of connections and floor beams occurring in areas surrounding columns 80 and 81, where similar conditions exist (i.e. asymmetric framing and similar span lengths), and other columns in the core perimeter, where similar conditions do not exist. See Figures 11.31 through 11.37 in NCSTAR 1-9 Volume 2.			
<b>Reason for Comment:</b>	Completeness			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A and 1-9	1A (p44) and 1-9 (p610)	1st full par./bullet 5 of objective 1/sent. 3 & 4	"Despite extensive thermal weakening of connections and buckled floor beams, fire-induced damage in the floor framing surrounding Column 79 over nine stories was the determining factor causing the buckling of Column 79 and, thereby, initiating progressive collapse."	<i>Add a sentence before the last sentence in the paragraph:</i> "Fire-induced damage to floor framing and connections around Columns 80 and 81 over nine stories contributed to the collapse of the building."

### SFRM THICKNESS AND BUILDING FIRE RATING

<b>Comment:</b>	WTC 7 was compliant with the NYCBC in all respects, including with respect to fire rating. The average measured SFRM thickness for the floor beams was 0.534 inches, which is larger than 0.5 inches required for 2 hour fire rating. The average measured thickness for the floor metal deck was 0.416 inches, which is larger than 3/8 inches required for 2 hour fire rating. These numbers indicate that the building met the fire resistance requirements of Type 1B (unsprinklered) construction. Code compliance of the SFRM is demonstrated in NCSTAR 1A page 7.			
<b>Reason for Comment:</b>	Correction of some inconsistencies in the text			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A	xxxiii	1st full par./1st and 2nd sent.	"The design of WTC 7 was generally consistent with the New York City Building Code of 1968 (NYCBC), with which, by policy, it was to comply. The installed thickness of the thermal insulation on the floor beams was below that required for unsprinklered or sprinklered buildings, but it is unlikely that the collapse of WTC 7 could have been prevented even if the thickness had been consistent with building code requirements."	<i>Change to:</i> "The design of WTC 7 was consistent with the New York City Building Code of 1968 (NYCBC), with which, by policy, it was to comply. "
1A	53	2nd bullet	"The type of building classification used to design and construct the building was not clear from the available documents. Based on the height, area, primary occupancy classification, and installation of a fire sprinkler and standpipe system, the minimum construction type (permitted by NYCBC) was type I-C (2 h protected) classification. However, some documentation, including some building drawings and specifications for bidders on the contract for applying SFRM to the structural steel, indicate a type I-B (3 h protected) classification."	<i>Delete first sentence and Change next two sentences to:</i> "Based on the height, area, primary occupancy classification, and installation of a fire sprinkler and standpipe system, the minimum construction type (permitted by NYCBC) was type I-C (2 h protected) classification. The fire resistance was designed to type I-B (3 h protected) classification."
1-9	11	par. 5/sent. 3	"Chapter 11 in NIST NCSTAR 1-1D gives a summary of fire protection measures used in WTC 7, which were consistent with a Type 1-C classification."	<i>Change to:</i> "Chapter 11 in NIST NCSTAR 1-1D gives a summary of fire protection measures for Type 1-C classification, which is the NYCBC classification for a sprinklered building. However, the fire protection measures used in WTC 7 were consistent with a Type 1-B classification."
1-9	11	par. 6/sent. 2	"The SFRM thickness measurements were consistent with a Type 1-B classification, with the exception of the floor system."	<i>Change to:</i> "The SFRM thickness measurements were consistent with a Type 1-B classification."

1-9	12	1st full par./1st and 3rd sent.	"Based on the SFRM measurements and project correspondence, the columns had SFRM thicknesses consistent with a 3 h fire resistance rating, the metal deck had SFRM thicknesses consistent with a 2 h fire resistance rating, and the floor framing (beams and girders) had SFRM thicknesses consistent with a 1 h fire resistance rating. ... In this report, Type 1-C classification was assumed, but the actual classification may have been type 1-B."	<i>Change to:</i> "Based on the SFRM measurements and project correspondence, the columns had SFRM thicknesses consistent with a 3 h fire resistance rating, the metal deck and the floor framing (beams and girders) had SFRM thicknesses consistent with a 2 h fire resistance rating. Although in this report, Type 1-C classification was assumed, NIST has since determined that the actual classification was Type 1-B."
1-9	81	section 4.7.2/bullet 2/sent. 2	"The bottom of the slab was insulated with 3/8 in. thick Monokote MK-5 to achieve a 1 h fire resistance rating."	<i>Change to:</i> "The bottom of the slab was insulated with 3/8 in. thick Monokote MK-5 to achieve a 2 h fire resistance rating."
1-9	85	Sect. 4.7.3 /bullet 3	"... (insulated for a 1 h rating), ..."	<i>Change to:</i> "... (insulated for a 2 h rating), ..."
<b>BUILDING CODE COMPLIANCE</b>				
<b>Comment:</b>	WTC 7 was building code compliant. The word "generally" suggests that there are some design issues not consistent with the NYCBC. The two raised issues in the report are the SFRM thickness and the stairwell size; as explained elsewhere in these comments, both met code.			
<b>Reason for Comment:</b>	Clarification			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A	xxxiii	1st full par. /first sent.	"The design of WTC 7 was generally consistent with ..."	<i>Delete:</i> "generally"
1A	xxxiii	1st full par. /last sent.	"The stairwells were narrower than those required by the NYCBC, but, combined with the elevators, were adequate for a timely evacuation on September 11, 2001, since the number of building occupants was only about half that expected during normal business hours."	<i>Delete sentence.</i>
1A	13	last sent.	"The stairwells, although somewhat narrow for the maximum possible 14,000 occupants (estimated using the formula in the NYCBC), were more than adequate to evacuate roughly one-third of that number in the building that morning."	<i>Change to:</i> "The stairwells were code compliant and more than adequate to evacuate all the tenants in the building on that day."
1A and 1-9	1 A (p45) and 1-9 (p 611)	objective 3/bullet 1	"The design of WTC 7 was generally consistent with the NYCBC."	<i>Delete:</i> "generally"
1A and 1-9	1A (p 51) and 1-9 (p617)	section 4.4.1 and 14.4.1, 4th bullet	"... if the building were occupied at the calculated maximum level (~ 14,000 people). "	<i>Change to:</i> "... if the building were occupied at the calculated maximum level (~ 12,000 people). "
1A and 1-9	1A (p 53) and 1-9 (p619)	section 4.5.2 and 14.5.2/ bullet 1	"NIST found no evidence to suggest that WTC 7 was not designed in a manner generally consistent with applicable building codes and standards."	<i>Delete:</i> "generally"
1-9	309	1st par./last sent.	"... 34,800 ft <sup>2</sup> , or 3,200 m <sup>2</sup> (41,600 gross ft <sup>2</sup> less 6,800 ft <sup>2</sup> of core space)."	<i>Change to:</i> "... 30,000 ft <sup>2</sup> , or 2,787 m <sup>2</sup> (41,600 gross ft <sup>2</sup> less 11,600 ft <sup>2</sup> of core space/non-occupied space)."
1-9	309	2nd par./1st sent.	"... maximum occupant floor load of 348 persons ... "	<i>Change to:</i> "... maximum occupant floor load of 300 persons ..."
1-9	309	1st Bullet	"Sufficient capacity for 348 persons would have required six units of exit width, or 3.35 m (132 in.)."	<i>Change to :</i> "Sufficient capacity for 300 persons would have required five units of exit width, or 2.79 m (110 in.)."

1-9	309	2nd Bullet	"Two equally sized stairwells meeting the design requirements of the NYCBC would have been at least 1.68 m (66 in.) wide each. Three stairwells, each 44 in. wide, would also have provided the minimum egress capacity for business occupancy floors."	<i>Change to</i> : "Two equally sized stairwells meeting the design requirements of the NYCBC would have been at least 1.40 m (55 in.) wide each." <i>Delete 2nd sent.</i>
1-9	309	4th par.	"... was not consistent with the NYCBC."	<i>Delete</i> "not"
1-9	315	Section 7.5.2, 3rd bullet	"... 348 persons per floor. Assuming approximately 40 occupied floors (ignoring mechanical floors and lobbies), this would yield a rough occupant load of approximately 14,000 persons."	<i>Change to</i> : "... 300 persons per floor. Assuming approximately 40 occupied floors (ignoring mechanical floors and lobbies), this would yield a rough occupant load of approximately 12,000 persons."
<b>FUTURE FACTORS THAT COULD HAVE MITIGATED STRUCTURAL COLLAPSE</b>				
<b>Comment:</b>	The introductory sentence incorrectly suggests that there were contemporaneous capabilities in the 1980's that could have altered the outcome .			
<b>Reason for Comment:</b>	Clarification			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A and 1-9	1A (p 55) and 1-9 (p 621)	section 4.6 and 14.6, 1st par.		<i>Strike out first sentence.</i>
<b>Comment:</b>	Current and contemporaneous practice did not consider thermal expansion effects as a design load case.			
<b>Reason for Comment:</b>	Clarification			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A and 1-9	1A (p 55) and 1-9 (p 621)	Sections 4.6 and 14.6/1st bullet	"More robust connections and framing systems to better resist the effects of thermal expansion on the structural system."	<i>Change to</i> : "Connections and framing systems expressly designed to resist the effects of thermal expansion on the structural system, a load currently not considered in practice."
<b>RECOMMENDATIONS</b>				
<b>Comment:</b>	In some places (e.g., Relevance to WTC 7), the text could be read to suggest: (1) the recommendations are particularly relevant to WTC 7, as opposed to all or most tall buildings designed according to current or contemporaneous standards, (2) what is actually a NIST proposed future standard is a current standard or one contemporaneous with the design of WTC 7, and (3) that the adoption of these proposed standards "would have" instead of "might have" averted the collapse. Given that the NIST report in Section 4.6 recognizes that future technologies show promise but have yet to be investigated, the language of the Recommendations should reflect the fact that some of these require further studies. For example, the adoption of performance-based design requires the specification of a "design basis fire". The possibility of a collapse can only be eliminated as long as an actual fire does not substantially exceed in extent or depart in character from the "design basis fire".			
<b>Reason for Comment:</b>	Context			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1A	58 (For example)	For example, Recomm. A, Relevance to WTC 7	"Had WTC 7 been expressly designed for prevention of fire-induced progressive collapse, it would have been sufficiently robust to withstand local failure due to fires without suffering total collapse."	<i>Change to</i> : "Had contemporaneous practice and standard been to expressly design buildings for prevention of fire-induced progressive collapse, WTC 7 might have been sufficiently robust to withstand local failure due to fires without suffering total collapse."
<b>Comment:</b>	Statement "which collapsed due to ordinary building fires " is inconsistent with the rest of the NIST report.			
<b>Reason for Comment:</b>	Consistency and Accuracy			
1A	64	last par. under 5.1.5	"...which collapsed due to ordinary building fires..."	<i>Delete</i>

CONSISTENCY OF TEXT AND FIGURES IN CHAPTER 11				
Comment:	Figures 11-23 to 11-29, 11-31 to 11-37, and 11-39 to 11-45 show the seated connections to have “no damage” in the vertical direction, indicating that these connections did not unseat. The occurrence of girder seat walk-off described in the text is not consistent with the figures.			
Reason for Comment:	Consistency			
Report #	Page #	Para./Sent.		
1-9	Chapter 11		See examples below:	
		(Vol1-9 p503)	"the girder... failed due to buckling, followed by walk off of the of the bearing seat (floors 12 and 13)" conflicts with figure 11-35 and 11-36	
		(Vol1-9 p504)	"the girders between columns 79 and 44 and Columns 26 and 81 had walked off the bearing seat at Column 79 and 81, respectively" conflicts with figure 11-36	
		(Vol1-9 p523)	"... girder between... 26 and... 81, which had buckled and walked off the bearing seat" conflicts with figure 11-29	
		(Vol1-9 p524)	"... had walked off the bearing seat.." (col 79 at 13th flr and col 81 at 12th flr) conflicts with figure 11-36	
		(Vol1-9 p525)	"... girder between column 26 and 81 buckled and walked off the bearing seat..." conflicts with figure 11-29	
		(Vol1-9 p525)	"... (2) walk off of seated connections..." conflicts with associated figures	
		(Vol1-9 p525)	"Loss of vertical support occurred when the beam or girder 'walked off' the bearing seat..." conflicts with associated figures	
		(Vol1-9 p534)	"At temperature less than approximately 400 deg C... girder walk off of seated connections... at Columns 79 and 81." conflicts with associated figures and 3.5 hr temperatures around column 81 appear to be higher than 400deg C in Figure 11-47.	
UNCERTAINTY IN COLLAPSE INITIATION				
Comment:	Uncertainties in the analyses affect the accuracy with which the collapse initiation sequence can be determined. As such, assertions that column 79 buckled first should be revised to reflect this degree of uncertainty by recognizing that the initiating event could have involved one or more of columns 79, 80 and/or 81. Prominent sources of uncertainty include the following: <ul style="list-style-type: none"><li>• The discrepancy in timing between the observed fires over approximately 6 floors and when their analytical representations in FDS occur in the Northeast corner suggests uncertainty in the ability to reliably establish the precise sequence of events leading up to the collapse of the building.</li><li>• The ANSYS model does not account for collapse initiation in its failure estimates and the sequence of floor failures is not represented in the analyses.</li><li>• Figure 11-49 shows the floor damage is widespread around columns 79, 80, and 81 and all three columns appear to have a substantial loss of lateral restraint over multiple floors prior to the collapse execution phase of the analysis.</li><li>• Discrepancy in time scales between the 1.3 second duration of the buckling sequence shown in figure 12-43 and the 4 hour period of the aggregated damage used to initiate the global collapse model suggests that the buckling sequence could be influenced by modeling approach.</li><li>• The global collapse analysis inherits all of the uncertainties inherent in the previous FDS, and ANSYS analyses as well as those associated with the global collapse analyses and the modeling assumptions that go with each of these.</li></ul>			
Reason for Comment:	Accuracy and Completeness			
Report #	Page #	Para./Sent.	Original Text	Suggestion for Revision
1A	19, 20, 43, 44, 47, 49, 50 and 82			Assertions that column 79 buckled first in actual fact (as opposed to what is shown in this specific analysis) should be revised to reflect the degree of uncertainty in the analyses by including the initiating event could have been one or more of columns 79, 80 and/or 81.
1-9	596-597, 601, 606, 609, 615-616			
1A	43	For example, last par.	"The probable collapse sequence that caused the global collapse of WTC 7 was initiated by the buckling of Column 79, which was unsupported over nine stories after local fire-induced damage led to a cascade of floor failures. The buckling of Column 79 led to a vertical progression of floor failures up to the east penthouse and to the buckling of columns 80 and 81"	Change to: "The probable collapse sequence that caused the global collapse of WTC 7 was initiated by the buckling of at least one of the Columns 79, 80 and/or 81, which was unsupported over multiple stories after widespread fire-induced damage led to a cascade of floor failures. The buckling of these columns led to a vertical progression of floor failures up to the east penthouse."

INITIAL LOCAL FAILURE FOR COLLAPSE INITIATION				
<b>Comment:</b>	Referring to figures 11-23 through 11-29, for example, the analyses show that numerous different failures occur between 3.5 hour and 4.0 hour scenarios over a widespread area.			
<b>Reason for Comment:</b>	Accuracy and Completeness			
Report #	Page #	Para./Sent.	Original Text	Suggestion for Revision
1A	19-20	bottom of 19, top of 20	"Fire induced thermal expansion of the floor system surrounding Column 79 led to the collapse of Floor 13, which triggered a cascade of floor failures. In this case, the floor beams on the east side of the building expanded enough that they pushed the girder connection Columns 9 and 44 to the west on the 13th floor... this movement was enough for the girder to lose its connection to Column 79. the displaced girder and other local fire-induced damage caused Floor 13 to collapse..."	<i>Change to:</i> "NIST's analysis shows that widespread fire-induced damage to the 13th floor framing system in areas around columns 79, 80 and 81 led to the collapse of a large area of the 13th floor onto other floors below which were already weekend by other fires. The collapse of multiple floors left columns 79, 80, and 81 laterally unrestrained to a degree sufficient to leave them unstable, triggering a cascade of failure leading to the ultimate collapse of the building."
1-9	603	Section 11	"Further thermal expansion of the floor beams pushed the girder off its seat, which led to the failure of the floor system surrounding Column 79 on Floor 13"	<i>Change to:</i> "NIST's analysis shows widespread fire-induced damage to the 13th floor framing system in areas around columns 79, 80 and 81 led to the collapse of a large area of the 13th floor onto other floors below which were already weekend by other fires. The collapse of multiple floors left columns 79, 80, and 81 laterally unrestrained to a degree sufficient to leave them unstable, triggering a cascade of failure leading to the ultimate collapse of the building."
INITIATING FAILURE TEMPERATURE				
<b>Comment:</b>	Assertions in the report that the collapse sequence occurs at temperatures below 400 degrees C do not appear to be supported by the analysis and tend to oversimplify the complex fire environment and misrepresent the behavior of the building.			
<b>Reason for Comment:</b>	Accuracy and Completeness			
Report #	Page #	Para./Sent.	Original Text	Suggestion for Revision
1A	19	6th par./2nd sent.	"This buckling arose from a process that occurred at temperatures at or below approximately 400°C (750 °F)..."	<i>Change:</i> "occurred" to "began to manifest in localized damage"
1A	32	5th par.	"... connections, floor beams, and girders were damaged or had failed at steel temperatures that were approximately 400° C..."	<i>Change to:</i> "... connections, floor beams, and girders were damaged or had failed at steel temperatures associated with the Case B scenario"
1A and 1-9	1A (p 49) and 1-9 (p 615)	2nd bullet	"The connection, beam, and girder failures in the floor systems, and the resulting structural responses, occurred at temperature below approximately 400° C..."	<i>Change to:</i> "The connection, beam, and girder failures in the floor systems occurred as a result of a process of complex behaviors. In some instances, that process began to initiate at temperature below approximately 400°C..."
1A and 1-9	1A (p 54) and 1-9 (p 620 )	4th bullet	"The thermal expansion of the WTC 7 floor beams that initiated the probable collapse sequence occurred at temperatures below approximately 400°C."	<i>Change to:</i> "The thermal expansion of the WTC 7 floor beams that participated in the probable collapse sequence, in some instances, began to initiate at temperatures below approximately 400°C. "
1-9	534	4th bullet	"girder walk off of seated connections... at Columns 79 and 81, and"	<i>Delete bullet. Related figures do not appear to support text. For instance, the 3.5 hr temperatures around column 81 appears to be higher than 400 deg C in Figure 11-47.</i>
1-9	534	7th bullet	"Many floor beams on Floors 12, 13 and 14 ... prior to beam temperatures reaching 400° C (averaged over the beam length)"	<i>Delete Sentence. Related figures do not appear to support text. For instance, comparing the temperatures in figure 11-47 with the buckled /failed members in figure 11-28, only three beams at the north side of the building can be identified as failing prior to 400 degrees.</i>
SHEAR STUD MODELING				
<b>Comment:</b>	It is difficult to judge with certainty how accurately the interaction of floor beams with the floor slab and decking has been captured in the various modeling efforts. It appears that the number of shear studs included in the ANSYS model of the floor beams is not consistent with the number of shear studs shown in the drawings. Floor beams in the northeast corner of the building are indicated in Figure 11-10 to have about 19 studs per beam while the excerpt from the erection drawings in Figure 8-16 indicates that there should be 28.			



<b>Reason for Comment:</b>	Consistency			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1-9	473	par. Above Fig 11-10	"The floor area where failure of floor framing connections and shear studs was modeled..."	<i>Include a note to describe how the discrepancy in the number of studs was accounted for in the modeling approach.</i>
<b>Comment:</b>	Shear stud failure criterion is derived on the basis of localized concrete failure due to stresses acting along the axis of a composite floor beam in order to determine if composite action is lost. However, it appears that the modeling approach for shear stud failure eliminates all horizontal connection between the floor slab and the beam in the event that the estimated stud capacity is exceeded, thereby also eliminating any horizontal restraint at the top flange of the beam. Given that non-composite beams are frequently designed as laterally restrained (roof beams are a common example) based solely on the nominal restraint provided by the decking alone, the assumptions behind this failure model should be clarified.			
<b>Reason for Comment:</b>	Consistency			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1-9	482	last par.	"...wherein failure occurred when the [...] SRSS of the force components in the x and y directions exceeded the temperature dependent shear capacity of the stud."	<i>Provide discussion of potential lateral restraint provided by decking.</i>
<b>Comment:</b>	The actual (as-built) number of shear studs on beams (and perhaps girders) may be more than what is specified on structural drawing S-8 revision H. Erection drawing sheets E8/9 through E44/45 incorporate a note for additional studs. This note placed for revision dated 11/12/85 states "Note for additional studs (X54)". And the statement at the bottom of the drawing sheets says "For additional studs see cust. dwg. S8 rev. I".			
<b>Reason for Comment:</b>	Consistency			
<b>Report #</b>	<b>Page #</b>	<b>Para./Sent.</b>	<b>Original Text</b>	<b>Suggestion for Revision</b>
1-9	14 and 15	last sent. of p.14, first sent. of p.15		<i>The existence of revision I of drawing S-8 developed for additional shear studs should be mentioned. If this drawing shows more studs on the beams or even studs on the girders, these additional studs should be incorporated into the thermal weakening analysis of the floor system.</i>
1-9	342	footnote 2		